AIRPACT: a numerical air-quality forecasting system for the Seattle area

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Outline

- Background on AIRPACT project
- Domain Map and Monitoring Network
- System Design
- Operations
- Examples: Forecast Results and Observations
- Evaluation of System Performance
- Upcoming changes
- Spin-off project: ClearSky

Background on AIRPACT
www.airpact.wsu.edu

- "Air Indicator Report for Public Access and Community Tracking"
- Funded 2000-2002 by EPA EMPACT program.
- Conceived as **part** of strategy to leverage monitoring data to further public education on AQ issues and public awareness of AQ conditions.
- Initial Domain has been Puget Sound Region.
- Ecology (Washington Department of Ecology) provides emissions.
- UW provides meteorological modeling support via daily forecast runs.
- WSU developed the AQ forecasting system.
- Washington Department of Ecology operates monitoring network.
- WSU developed the verification system, as an adjunct to the system.
- AIRPACT forecasts were provided during the PNW2001 campaign.
- Particulate tracer added, based on emissions from Ecology.

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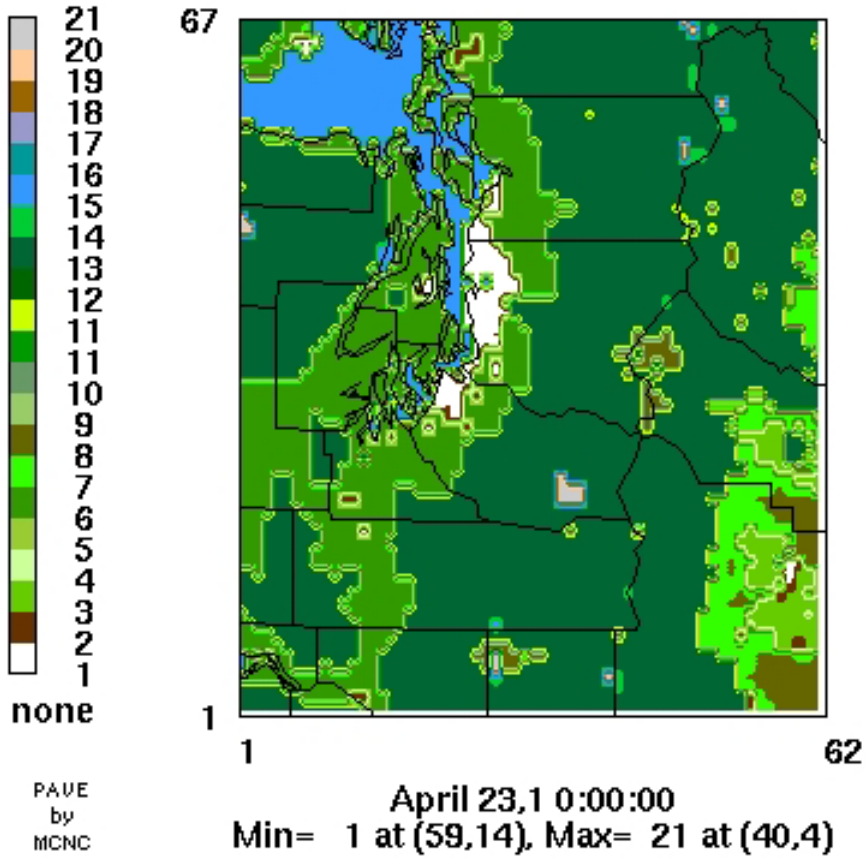
Puget Sound LANDUSE

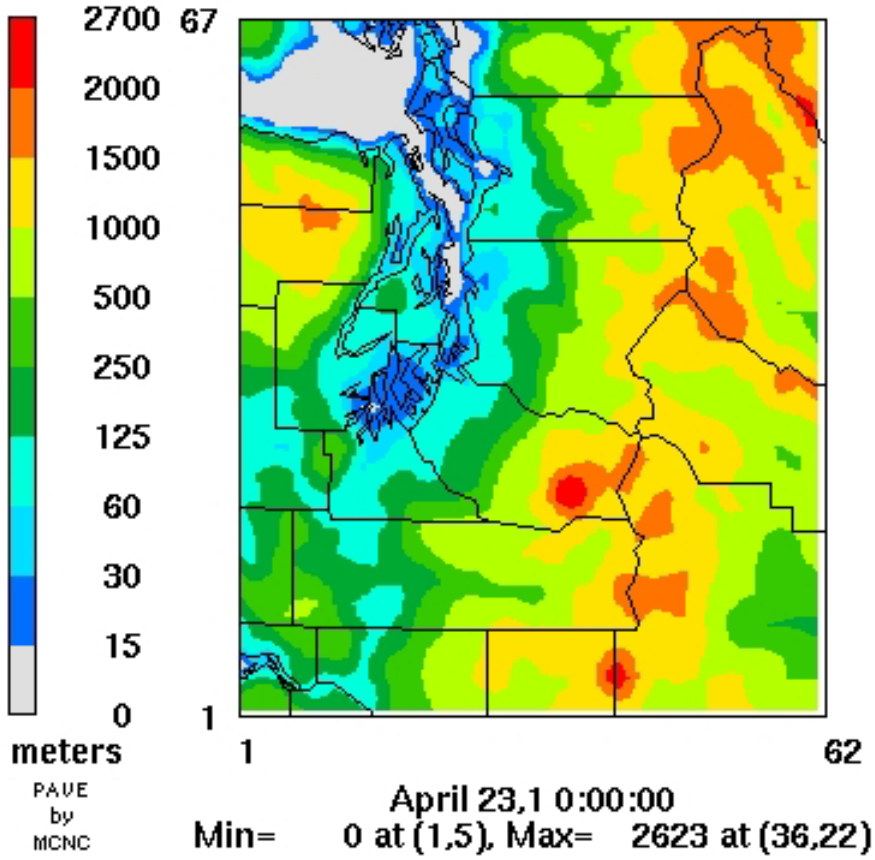
from 26 MM5 (USGS) types
AIRPACT 4-km Domain



April 23,1 0:00:00
Min= 1 at (59,14), Max= 21 at (40,4)

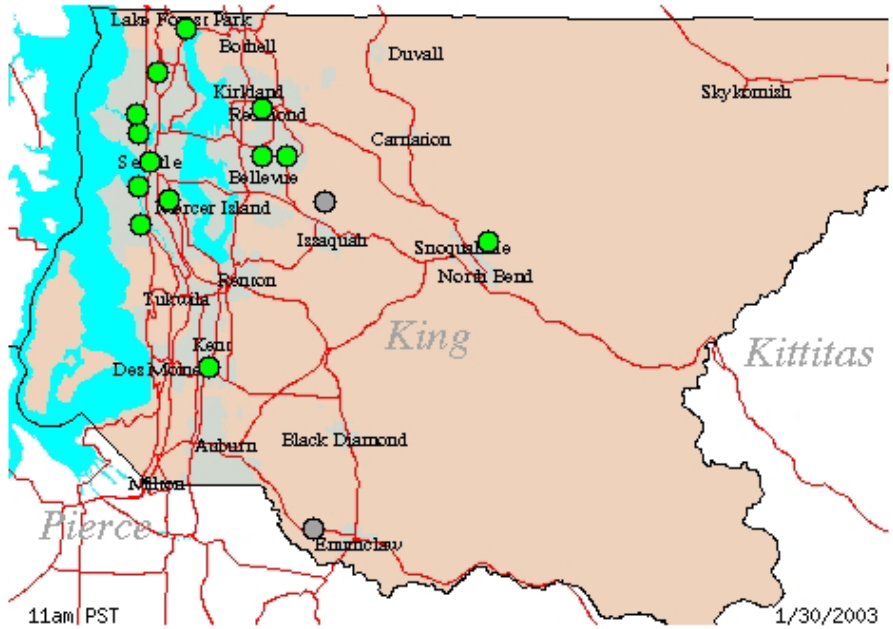
CALMET ELEVATIONS

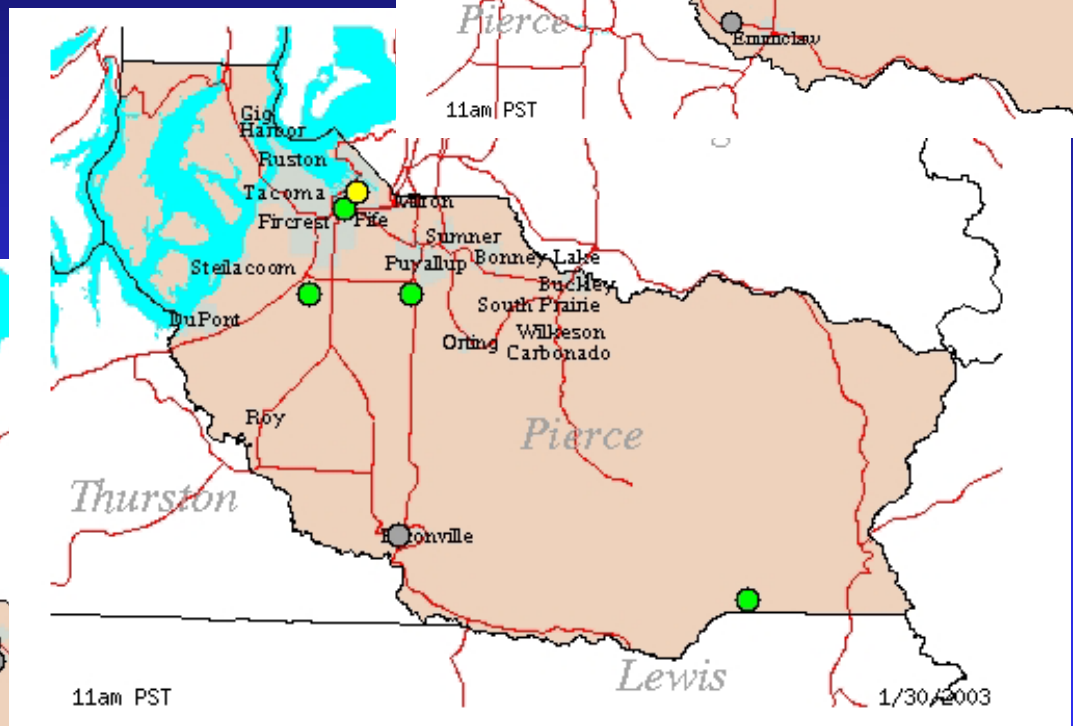
meters, from MM5
AIRPACT 4-km Domain

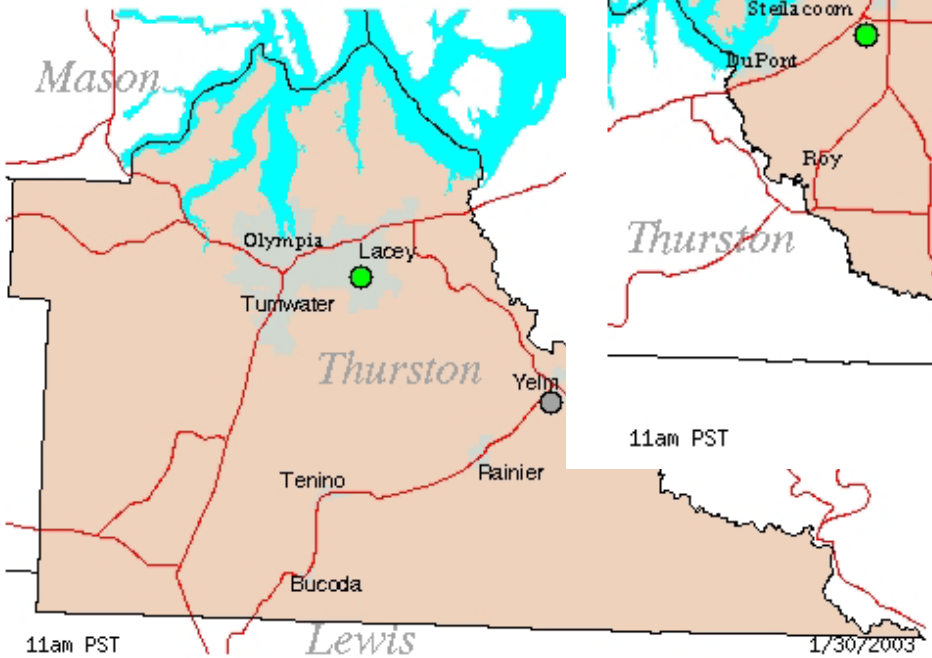


April 23,1 0:00:00
Min= 0 at (1,5), Max= 2623 at (36,22)

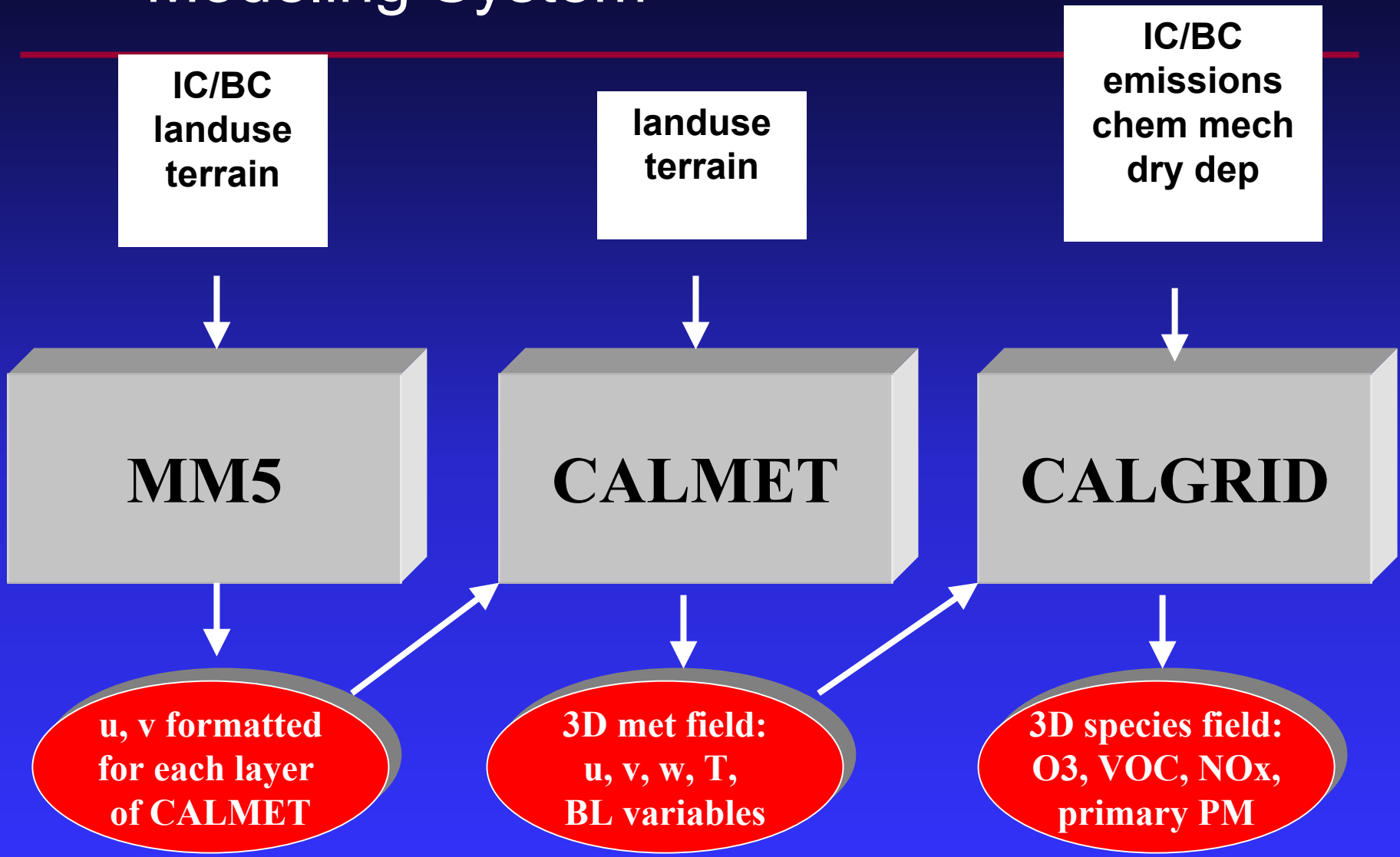
Monitoring Network Sites







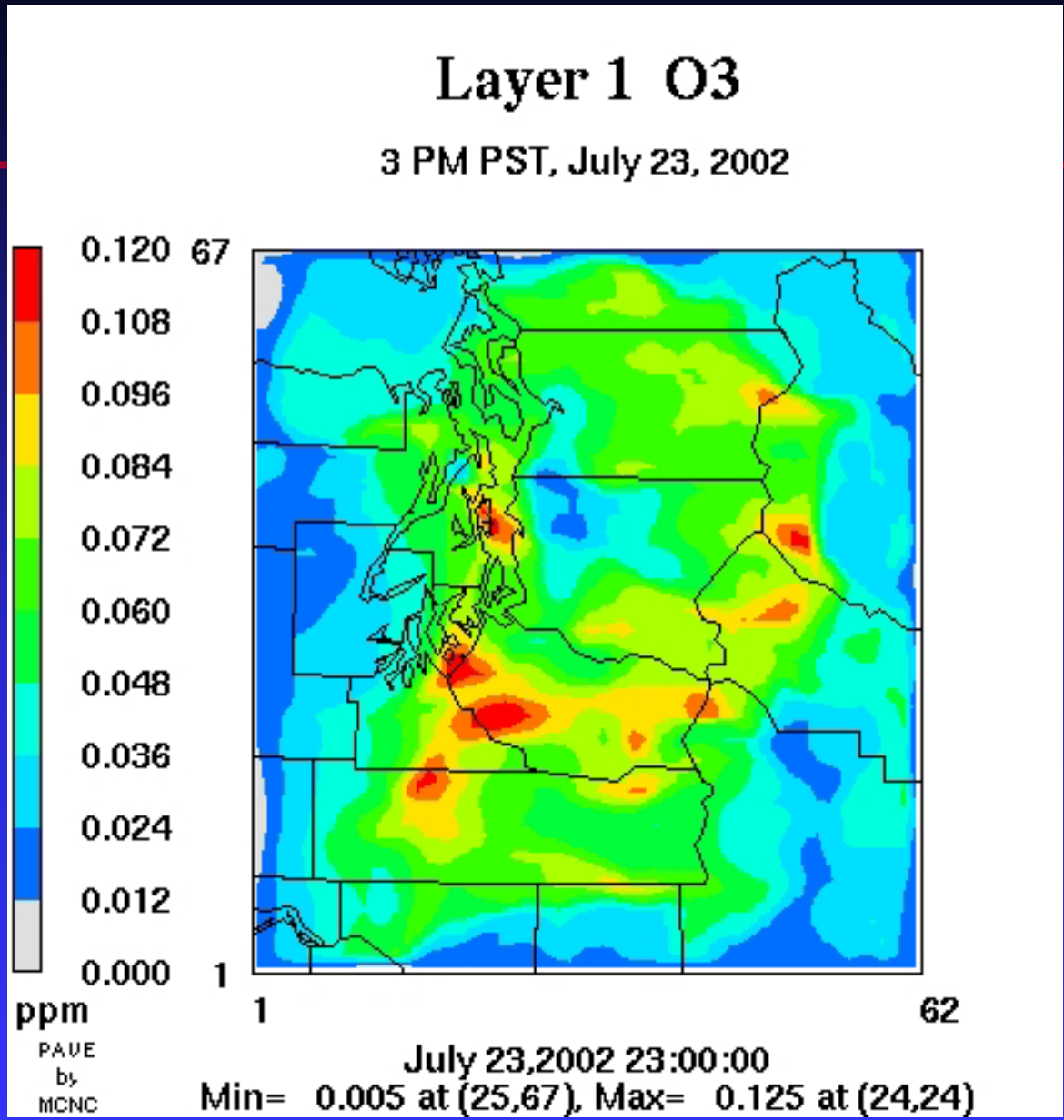
AIRPACT Regional Air Quality Modeling System



AIRPACT Operations

- Overnight Run (almost) Every Night
  - Starts after the UW MM5 4-km run (0 Z initialized).
  - Uses forecast hours 12--36 from MM5 run.
  - 24-hour CALGRID run on DEC/Alpha (one processor) runs in ~70 min CPU time.
  - Currently finishes by ~ 3 AM PST.
- Verification w/ Automated Network Observations (un-validated)
  - One day later than forecast.
- Forecast Results post-processed into web-based animations, automatically.
- Verification results post-processed to web as site-species plots of observations and predictions.
- Automated ftp delivery.

www.airpact.wsu.edu



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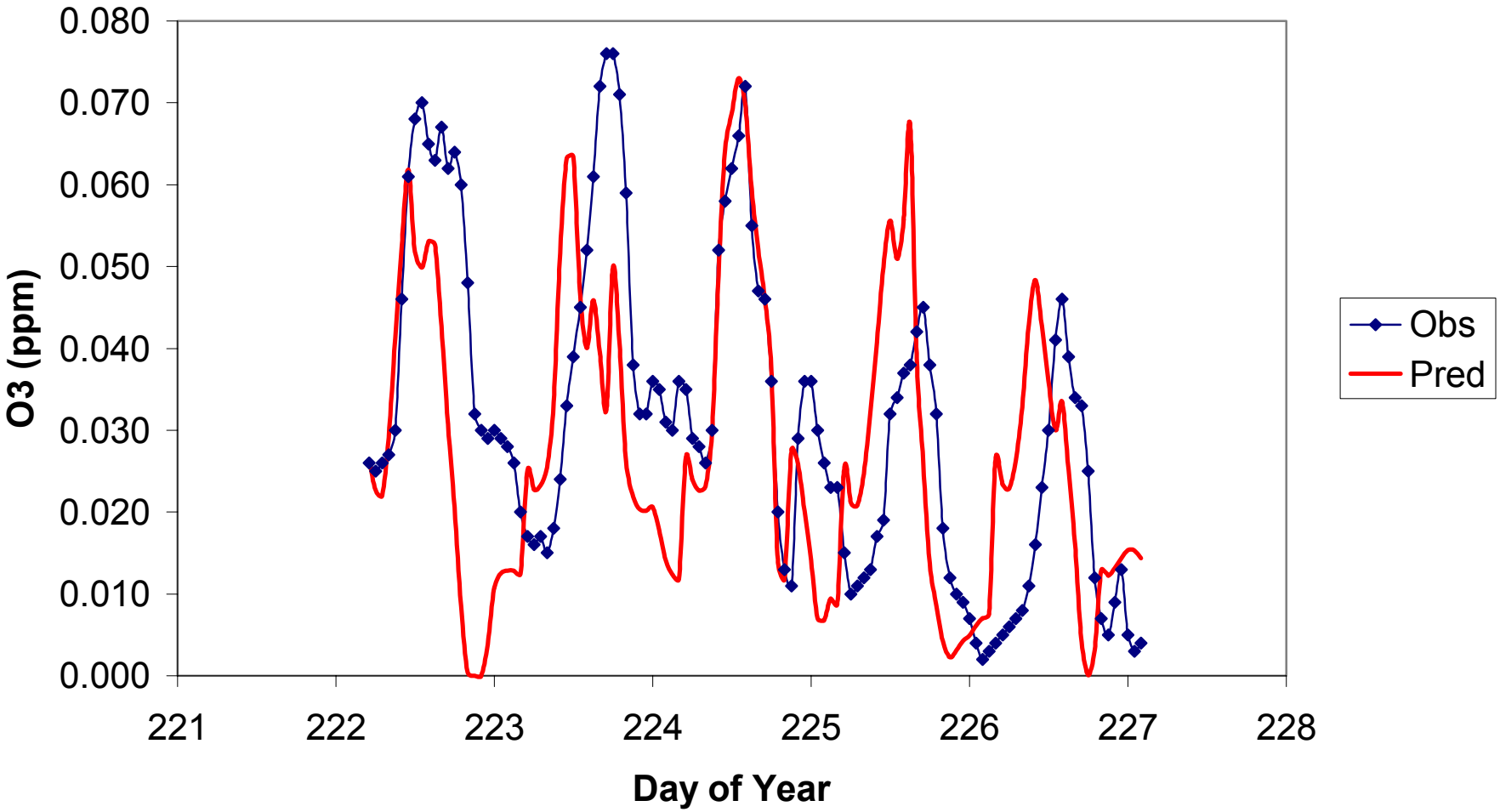
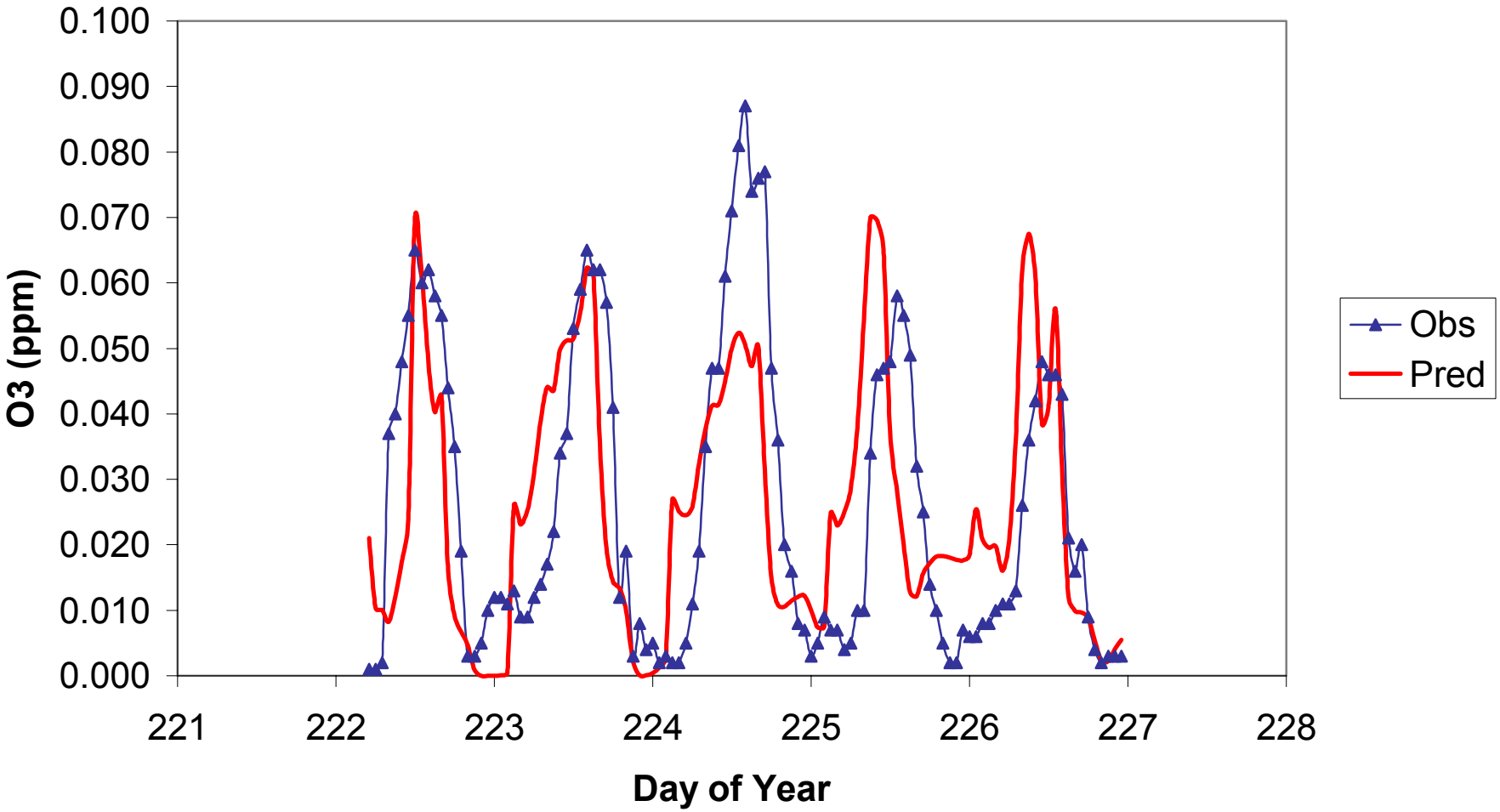
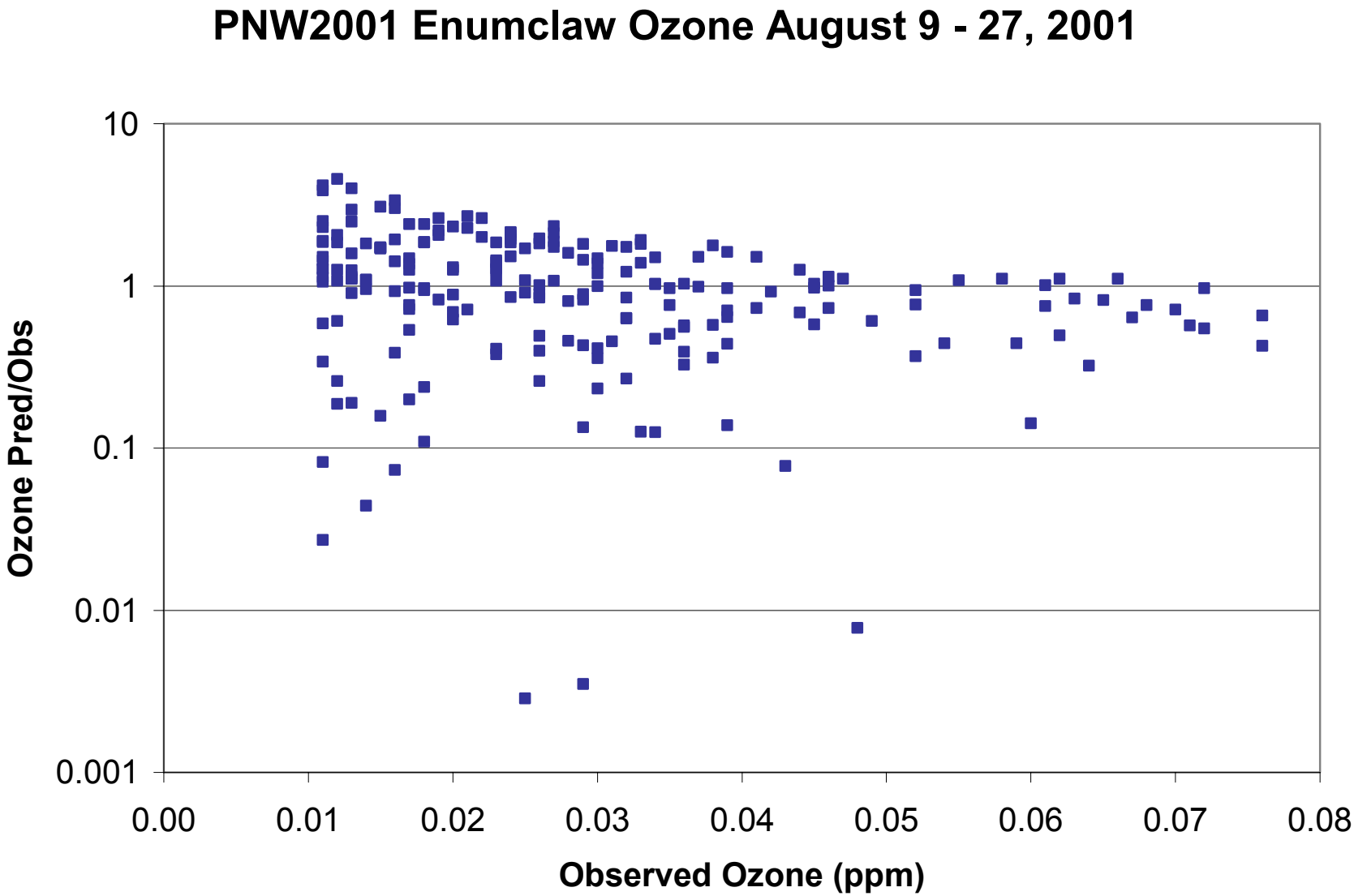
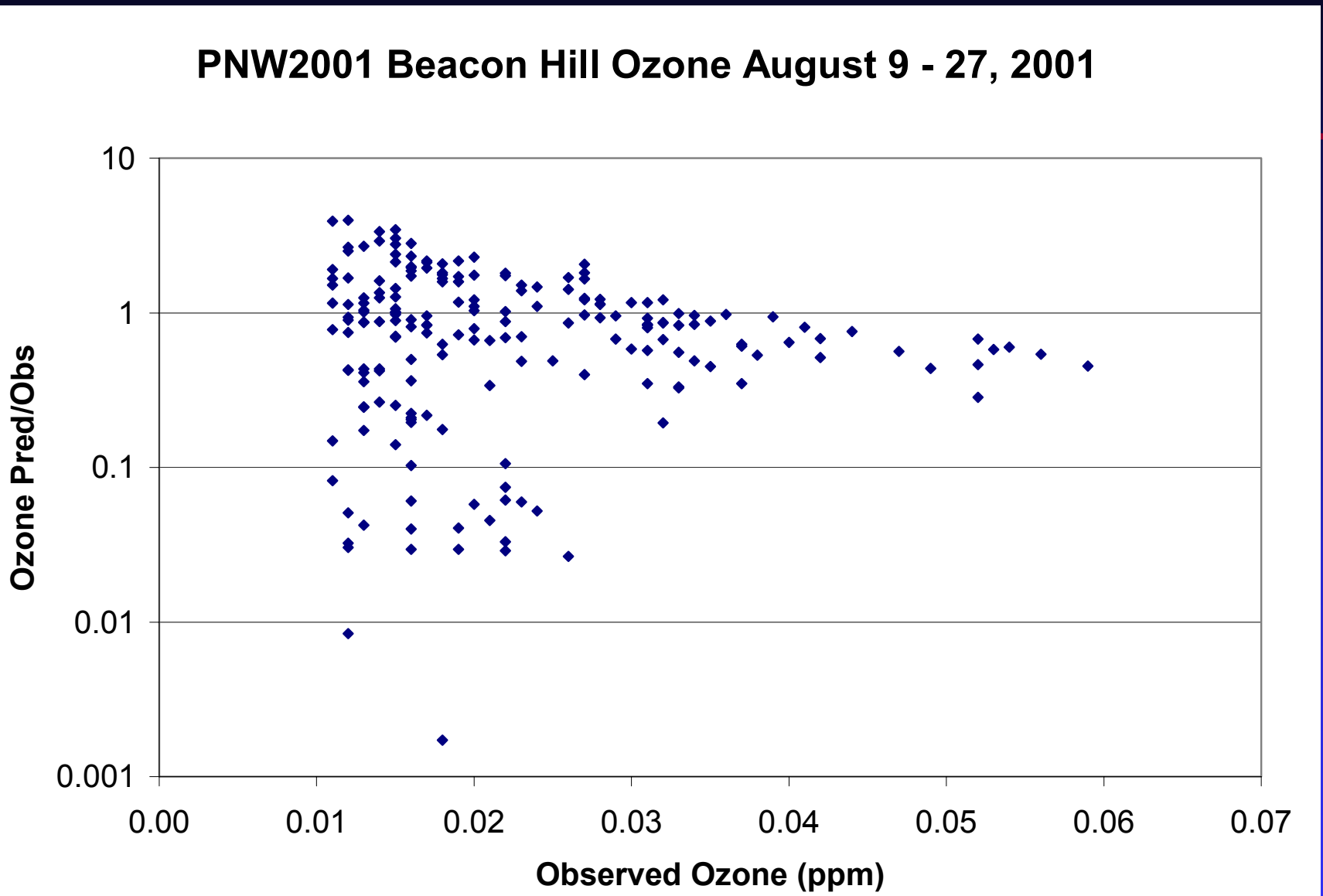
Summer 2001 Ozone Predictions with Paired Observations (during PNW2001)

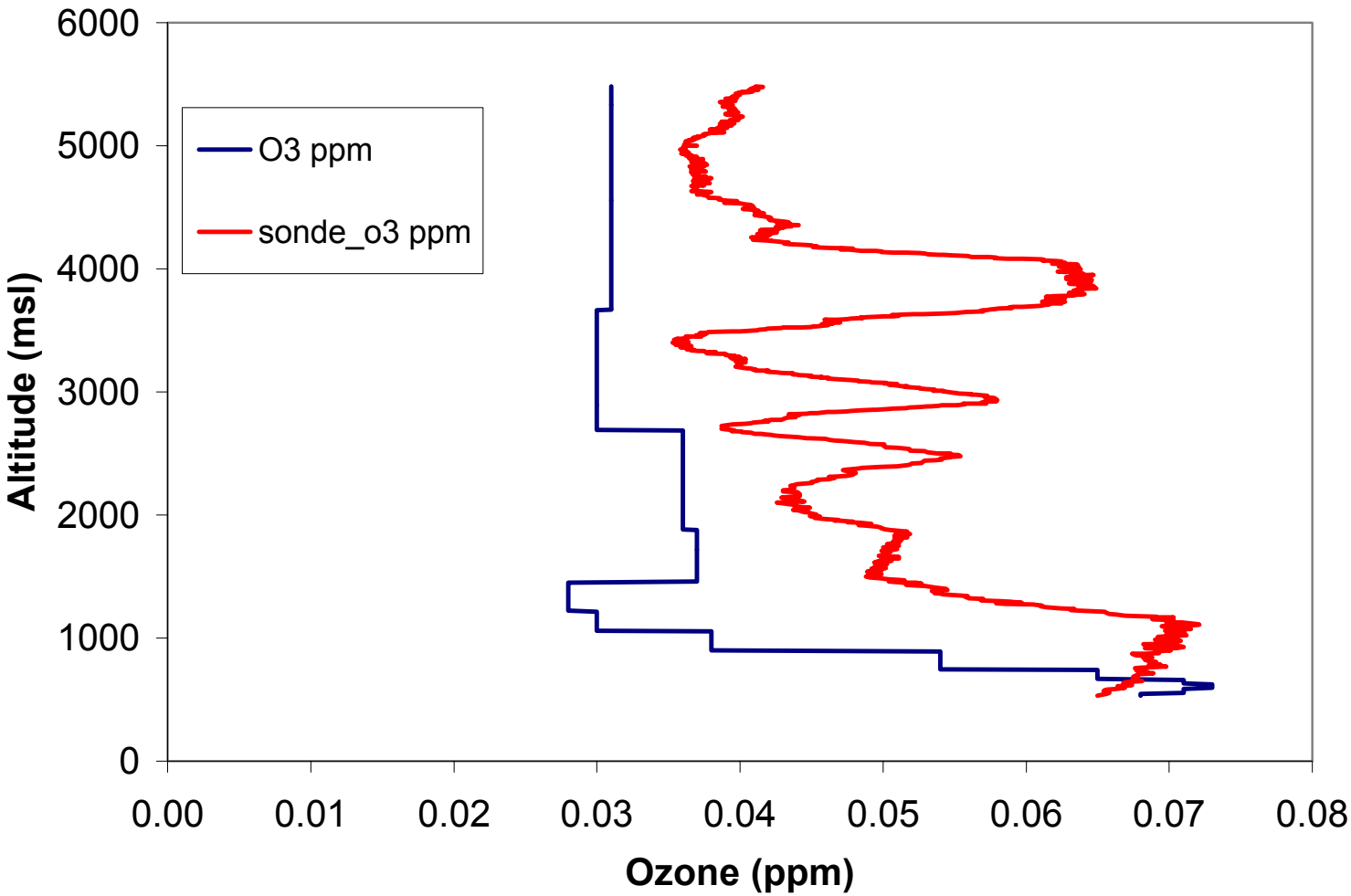

PNW 2001 O3 Enumclaw Forecast
Aug 10 - 14, 2001
O3 (ppm)
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
221
222
223
224
225
226
227
228
Day of Year
Obs
Pred


PNW 2001 O3 Yelm Forecast
Aug 10 - 14, 2001
O3 (ppm)
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
221
222
223
224
225
226
227
228
Day of Year
Obs
Pred


PNW2001 Enumclaw Ozone August 9 - 27, 2001
Ozone Pred/Obs
10
1
0.1
0.01
0.001
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
Observed Ozone (ppm)


PNW2001 Beacon Hill Ozone August 9 - 27, 2001
Ozone Pred/Obs
10
1
0.1
0.01
0.001
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
Observed Ozone (ppm)

PNW 2001 Ozone Profiles at Enumclaw 8/26/01



AIRPACT Diesel Particulate Modeling

- Particulate diesel emissions from WA Dept. of Ecology for mobile and area sources
- No secondary particulate chemistry or physics
- Particulate conserved as a tracer
- Statistics being accumulated for analysis of patterns of population exposure.
- Verification using PM2.5 (?)

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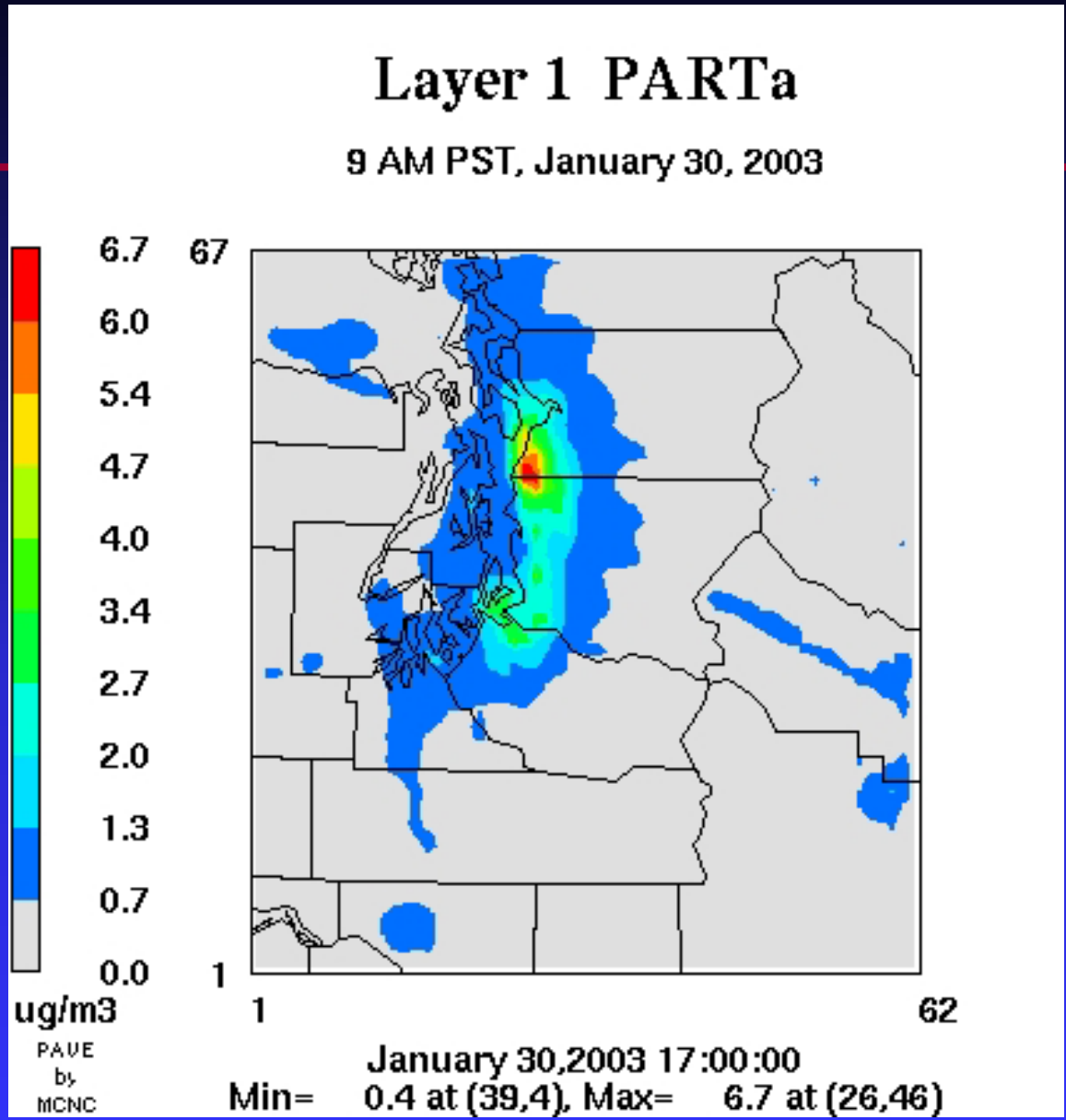


AIRPACT Evaluation Elements

Evaluation of Paired Observations and Predictions (current)

Upgrading Verification to perform quasi-validation on monitor network data.

Conversion of Observations and Predictions to AQI values, for comparison.

Development of integrated database for analysis, integrating met and model output files with metadata (OpenDX)

Table 1. Summary of model ozone-performance statistics for August 2001.

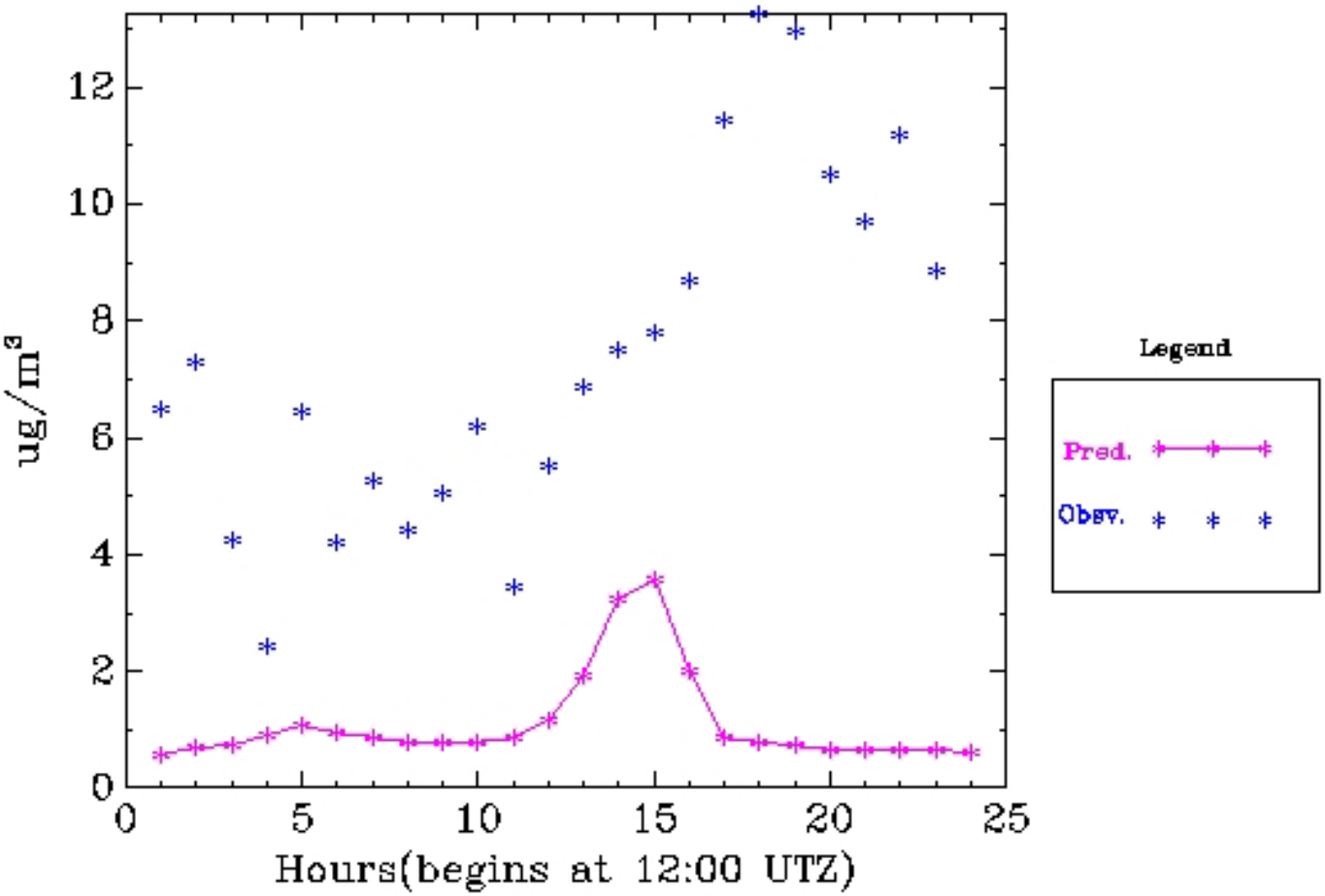
OZONE AUG. 2001	Mean	Stdev	Max	Bias (%)	Gross Error (%)
Enumclaw				23	60
Issaquah				2	47
North Bend				46	63
Pack Forest				22	53
Rainier				-6	35
Seattle				-5	56
Yelm				27	54
All Sites				**15**	**51**
Obs (ppb)	29	15	98		
Pred (ppb)	25	16	101		
P/O	1.1	0.7			

Table 2. Summary of model ozone performance statistics for July 2002

OZONE JULY 2002	Mean	StDev	Max	Bias (%)	Gross Error (%)
Enumclaw				**-5**	**41**
Issaquah.				**-32**	**54**
North Bend				**1**	**49**
Pack Forest				**-3**	**50**
Rainier .				**6**	**36**
Seattle				**-33**	**63**
Yelm				**-6**	**46**
All Sites				**-10**	**49**
Obs [ppb]	30	15	99		
Pred [ppb]	25	18	104		
P/O	0.9	0.6			

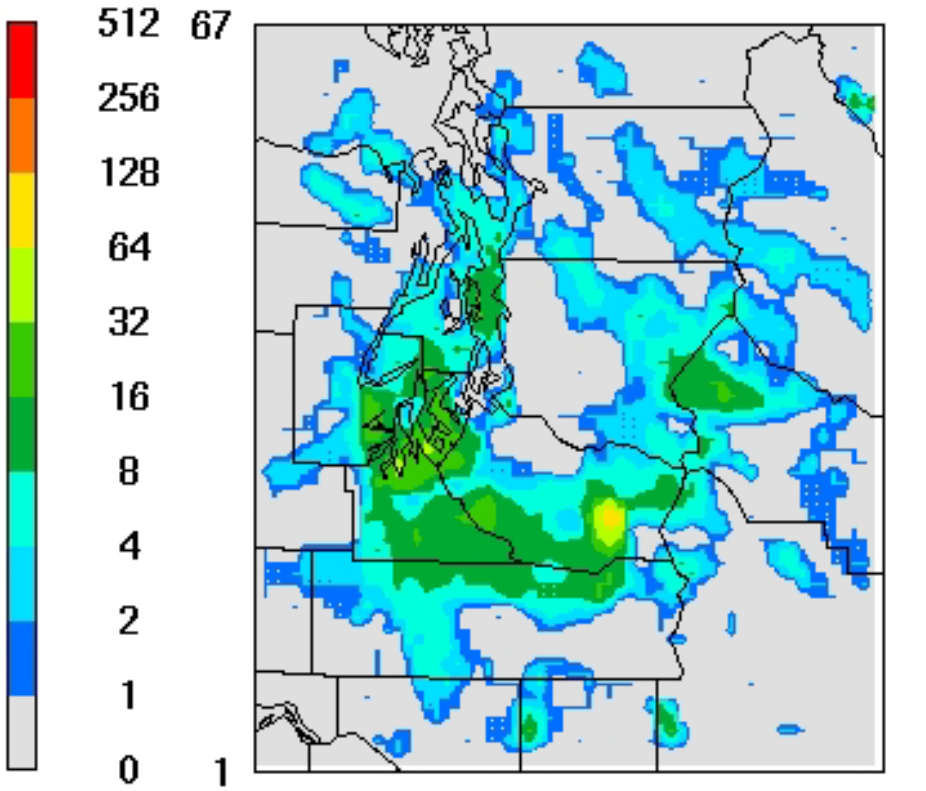
AREA_EMISSIONS				WINDS	CALGRID	VERIFICATION	CUMULATIVE
Area	Biogenic	Mobile	Total		Predicted_Contours	by_Species_Site	STATISTICS
CO	ACET	ARO1	ARO1	SLP	ALK1	CO_YAKS4	DP_MAX
HCHO	ISOP	CO	CO		ARO2	O3_NBDNBDWY	DP_24h_avg
NOX	OLE3	NOX	NOX		CO	O3_RAIJACK	DP_24h_max
OLE2			PART		NOX	CO_0770009	DP_GE_15
					O3_500m	CO_BLVBLV_1	DP_GE_40
					O3_AQI	CO_BLVBLV_2	DP_GE_65
					O3_Y31	CO_BLVNE8	O3_hrs_GE_120
					O3_Y62	CO_EVTBDY_2	O3_hrs_GE_80
					O3	CO_EVTBRDWY	O3_Cnt_8hr_GT_65
					OLE1	CO_LYN44AVW	O3_Cnt_8hr_GT_80
					OLE2	CO_SEA4PIKE	O3_Max_hr
					OLE3	CO_SEABEACN	O3_Cum_Max_8hr
					PART	CO_SEANE45	O3_Run_Max_8hr

AIRPACT graphics products include animations of emissions, meteorology and forecast air quality, plus verification plots and cumulative statistic products (examples).


PART at SEADUW on 01/01/2003
ug/m3
0
2
4
6
8
10
12
0
5
10
15
20
25
Hours(begins at 12:00 UTZ)
Legend
Pred.
Obsv.

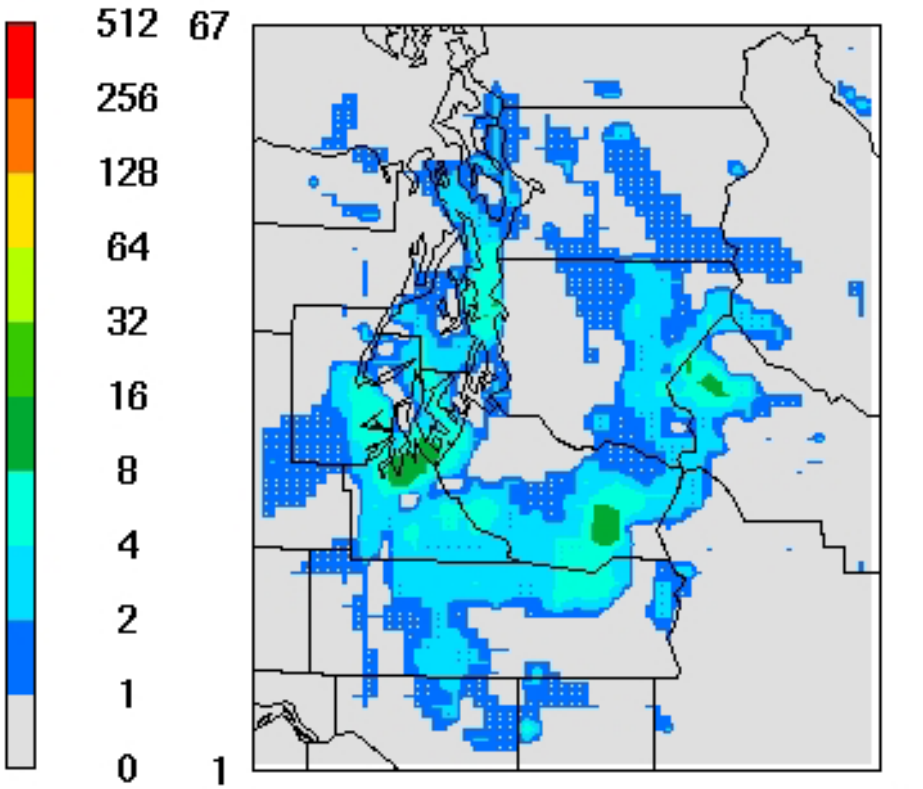
Cell–hours exceeding 80 ppb O3

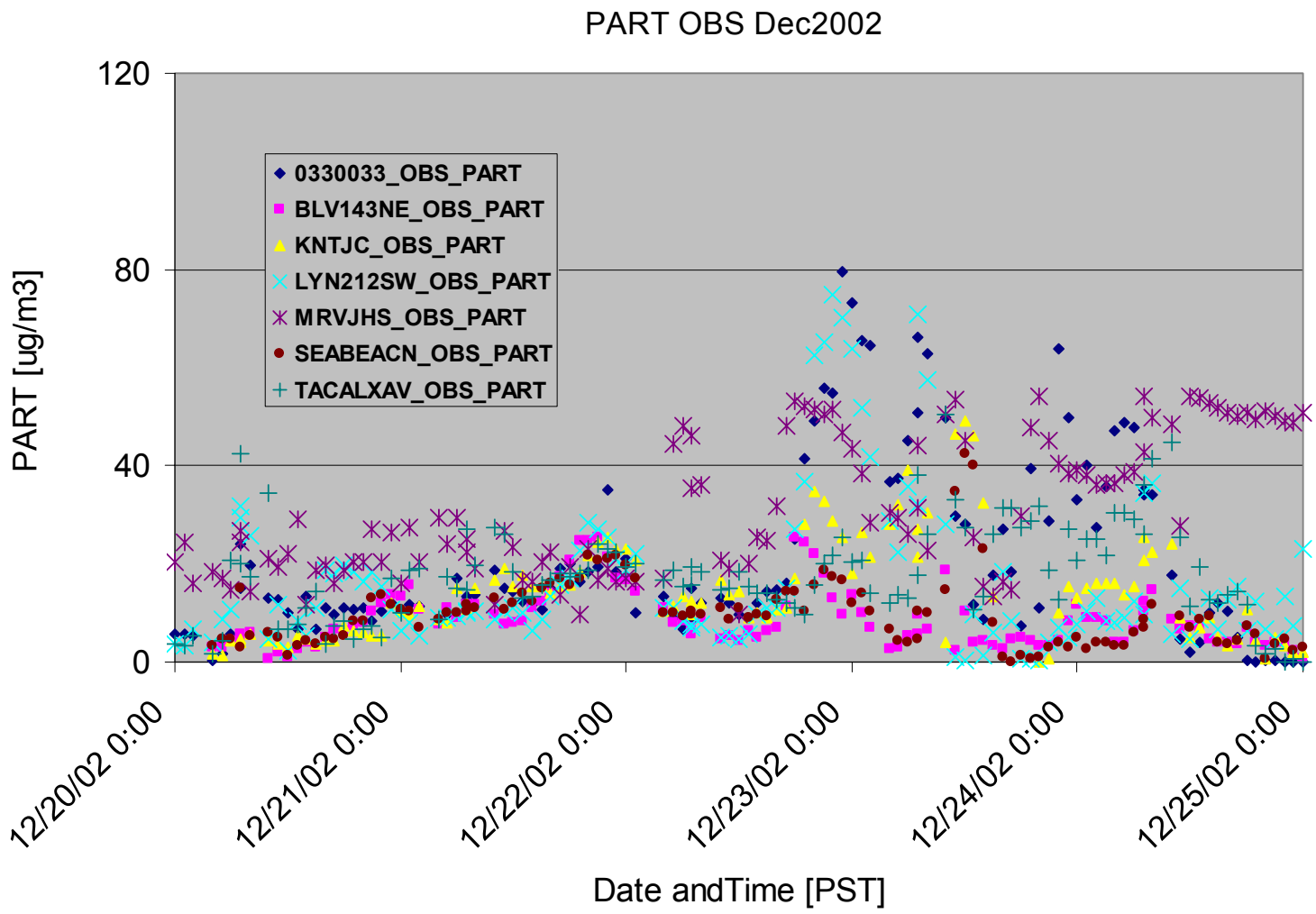
as of 20030101 simulation,
since 20020601



Days w/ 8-hr-avg O3 GT 65 ppb

as of 20030101 simulation,
since 20020601




PART OBS Dec2002
120
80
40
0
PART [ug/m3]
0330033_OBS_PART
BLV143NE_OBS_PART
KNTJC_OBS_PART
LYN212SW_OBS_PART
MRVJHS_OBS_PART
SEABEACN_OBS_PART
TACALXAV_OBS_PART
12/20/02 0:00
12/21/02 0:00
12/22/02 0:00
12/23/02 0:00
12/24/02 0:00
12/25/02 0:00
Date andTime [PST]

AIRPACT Modification Underway

Domain expansion south into Oregon

Addition of additional tracer species for Urban Air-Toxics Study

Conversion from CALGRID to CMAQ

AIRPACT Modifications for Urban Air-Toxics Study

Tracers for VOCs:

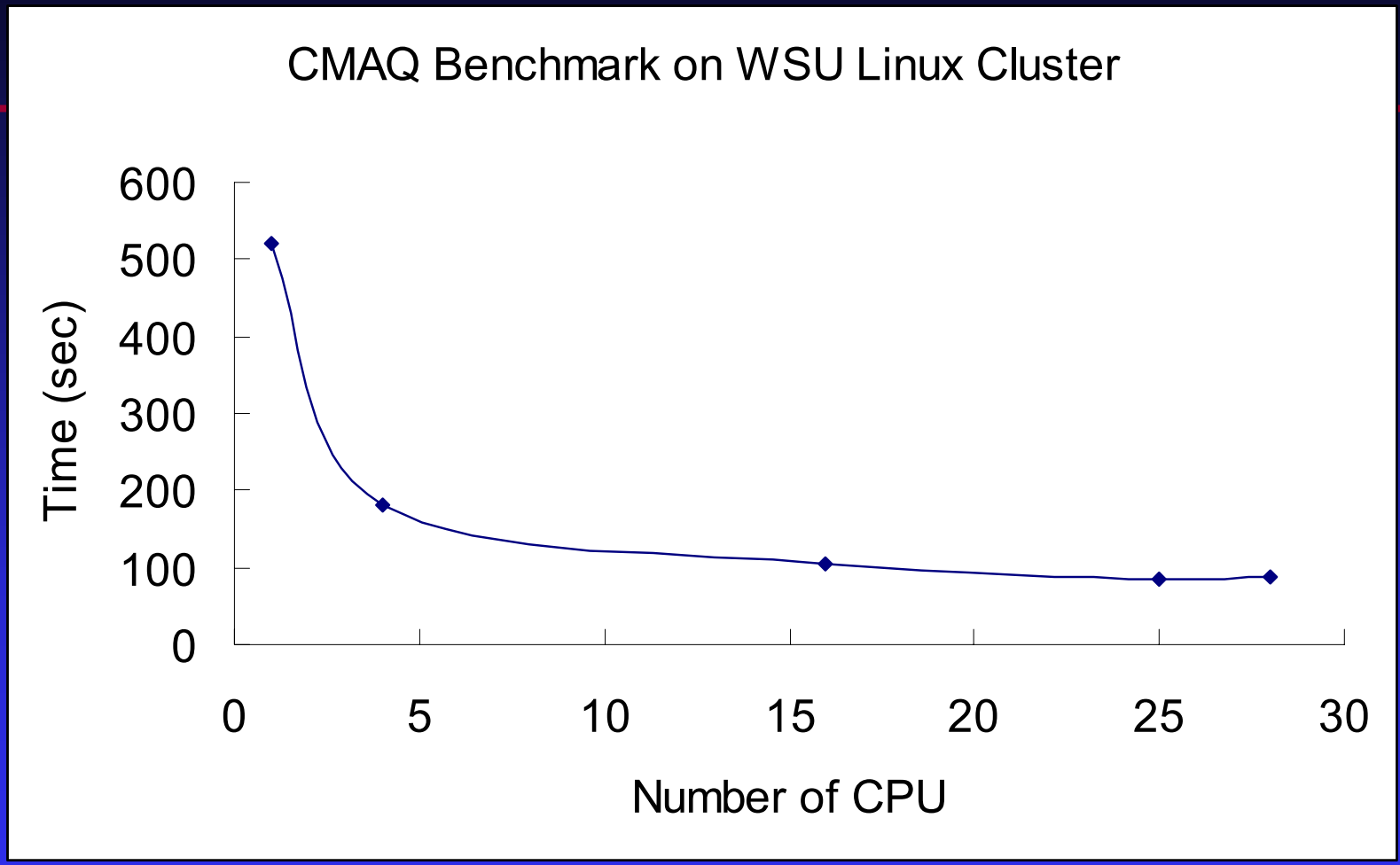
- 1-3-pentadiene
- Benzene
- Acetaldehyde
- Formaldehyde
- Perchloroethylene

Tracers for PAHs:

- Phenanthrene
- Naphthalene
- Fluoranthene
- Fluorene
- Pyrene

Tracers for PM5.2:

- *Diesel*
- Wood-smoke
- Total



Cluster work by Jack Chen with EPA parallel CMAQ model and assistance from NRC (Canada).

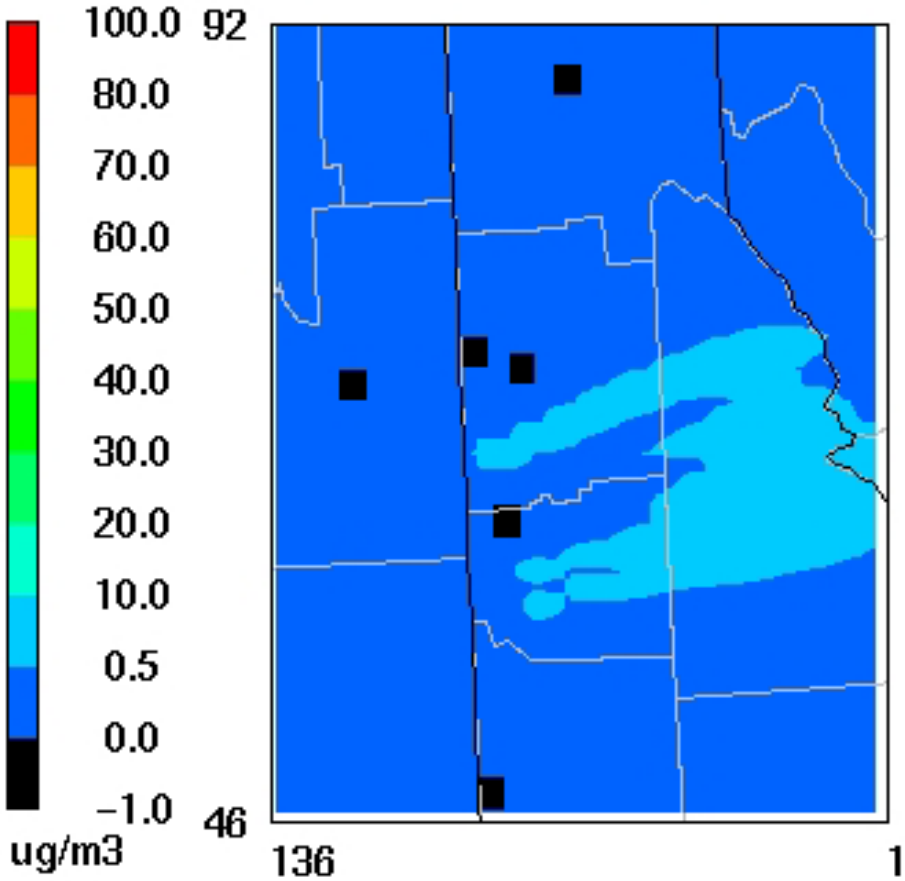
Spin-off Project ClearSky:

- Approached in Spring ’02 by Idaho DEQ to provide technical support for smoke management relating to agricultural burning.
- Proposed modified version of AIRPACT, now called ClearSky, using CALPUFF in place of CALGRID, to simulate plume dispersion.
- ClearSky system was used during Summer ’02 season in Northern Idaho and is being expanded/applied to Eastern Washington.

www.airpact.wsu.edu/clearsky/index.html

See the visitors area, please

CALPUFF PM2.5 simulation



Acknowledgments

- Funding through EPA EMPACT program, with additional support from the Puget Sound Clean Air Agency and Washington Dept. of Ecology.
- Assistance from Staff at UW.
- Benefited from codes/assistance by:
  - Mike Barna (now at CIRA).
  - Guangfeng Jiang (now at PNL).
  - Susan O'Neill (now at Forest Service FERA Lab).
- Support for netCDF and PAVE use from MCNC Environmental Programs group.

Conclusion….

Thanks for your attention!

Questions and Comments?